Variations of Meridional Aerosol Distribution and Solar Dimming

Contributors

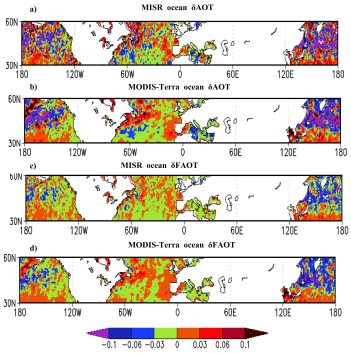
Chuck N. Long, *Pacific Northwest National Laboratory*; Pavel Kishcha, *Tel-Aviv University*; Boris Starobinets, *Tel-Aviv University*; Olga Kalashnikova, *Jet Propulsion Laboratory*; Pinhas Alpert, *Tel-Aviv University*

Research Highlight

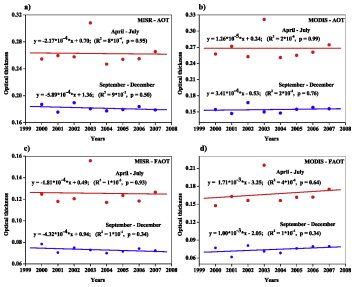
Atmospheric aerosols and clouds are two main factors that modulate the solar radiation reaching the Earth's surface, thus they play an important role in the reported changes in solar radiation at the Earth's surface known as the dimming-brightening phenomenon. Considerable recent attention has been focused on the direct effect of aerosols on the modulation of surface solar radiation. In cloudless conditions, aerosol trends could account for most of the solar dimming-brightening. To quantify the aerosol effects on the modulation of surface solar radiation, a detailed knowledge of aerosol distributions in space and time is necessary. Satellite remote sensing of aerosols provides us with an opportunity to estimate space and time distributions of aerosol radiative properties over the entire globe, albeit with less uncertainty over the ocean than over the land.

Meridional distribution of aerosol optical thickness (AOT) over the ocean was analyzed by using the eight-year multi-angle imaging spectrometer (MISR) and moderate-resolution imaging spectroradiometer (MODIS)-Terra data sets, from March 2000 to February 2008, as well as the five-year MODIS-Aqua data set, from July 2002 to June 2007. The three satellite sensors show that there was a pronounced meridional aerosol asymmetry. It was found that there were strong seasonal variations in the meridional aerosol asymmetry: it was most pronounced in the April – July months. There was no noticeable asymmetry during the season from September to December. The Northern hemisphere, where the main sources of natural and anthropogenic aerosols are located, contributed to the formation of noticeable aerosol asymmetry. During the season of pronounced hemispheric aerosol asymmetry, an increase in AOT was observed over the Northern hemisphere, while a decrease in AOT was observed over the Southern hemisphere. At mid-latitudes in the Northern hemisphere (30N – 60N), the main contribution to seasonal variations of AOT over the ocean was made by Pacific Ocean aerosols. At low latitudes in the Northern hemisphere (0N – 30N), aerosols over the Atlantic Ocean contributed to seasonal variations of AOT more significantly than aerosols over the Pacific Ocean. During the eight-year period under consideration, the brightening phenomenon, detected over the land, was not observed over the ocean at mid-latitudes 30N - 60N in cloudless conditions.

Analysis of the eight-year time series of ocean AOT shows that there is no statistically significant tendencies in AOT either in April – July, the season of pronounced meridional aerosol asymmetry, or in September – December, the season without noticeable aerosol asymmetry. Linear fits to the data are not statistically significant, thus by implication under cloudless conditions, statistically significant solar brightening caused by direct aerosol effects was not observed over the ocean at latitudes 30N - 60N during the eight-year period under consideration. Previous studies based on pyranometer data



The distribution of four-year aerosol differences (#AOT/#FAOT) between the last four years (March 2004 - February 2008) and the first four years (March 2000 - February 2004) at latitudes between 30N – 60N for the season of the most pronounced meridional aerosol asymmetry, from April to July: #AOT over the ocean (a – MISR, b - MODIS-Terra) and #FAOT over the ocean (c – MISR, d - MODISTerra).



Eight-year time series of MISR (left) and MODIS-Terra (right) aerosol data averaged over the ocean in the latitudinal zone 30N – 60N: (a - b) aerosol optical thickness, and (c-d) fine aerosol optical thickness. The plotted linear fits are not statistically significant.

Office of Science
U.S. DEPARTMENT OF ENERGY

from the global network show that significant solar dimming was not observed over sparsely populated sites, remote from the main industrial zones. This is even more relevant to remote ocean areas since they are thousands of kilometers distant from highly populated and/or industrial zones. Note, however, that the pyranometer data include both cloud and aerosol effects on surface solar radiation. In the current study, long-term aerosol variations were analyzed in cloudless conditions only.

Reference(s)

Kishcha P, B Starobinets, O Kalashnikova, CN Long, and P Alpert. 2009. "Variations of Meridional Aerosol Distribution and Solar Dimming." Journal of Geophysical Research – Atmospheres, , . ACCEPTED.

Working Group(s)

Aerosol, Radiative Processes